Chapter 4: Interactions within the biotic component of the biocenosis

4.1 Definition

Competition for resources and living space (food, territory, shelter, etc.) occurs both intraspecifically and interspecifically. It becomes more intense when the ecological requirements of the organisms are similar, when resources are limited (scarcity), or when population density is high.

In dense plant populations, competition mainly occurs for light, while in dry environments, it is mostly for water. When the roots of different species are intertwined, they are in direct competition. Competition often manifests as a struggle for existence: species best adapted to the local conditions eliminate less-adapted species. Among the latter, those with rapid growth may dominate and suppress others. Competition is particularly severe when individuals are morphologically similar, as they have comparable abilities to exploit resources.

In general, the species favored are:

- those that find local conditions close to their ecological optimum,
- those with long rhizomes, stolons, or efficient vegetative reproduction,
- those with rapid growth rates.

Other strategies reducing competition for water and mineral nutrients include stratification of root systems, which allows species to exploit different soil layers. Aerial stratification, on the other hand, primarily responds to competition for light.

In any ecosystem, multiple species coexist, interacting in various ways. The most important interactions between populations are:

- Competition,
- Predation,
- Mutualism.

Other interactions also exist, such as commensalism, symbiosis, and parasitism.

4.2 Interactions among living organisms

Biological interactions refer to all the relationships that occur among organisms within an ecosystem. They play a fundamental role in shaping community structure, population dynamics, and the overall functioning of natural environments. Among these interactions, **competition** represents one of the major ecological mechanisms.

4.2.1 Competition

Competition is a negative interaction (–/–) that occurs when several organisms use, or attempt to use, the same resource, resulting in a disadvantage for each of the interacting partners. It arises in the following situations :

- when individuals of the same species or of different species exploit a limited resource (food, water, light, nutrients, space, etc.);
- when resources are not strictly limited, but the simultaneous presence of organisms causes direct or indirect interference, for example in access to shelter, resting sites, nesting sites, or areas favorable for thermoregulation.

Two main types of competition can be distinguished:

a) Intraspecific competition

Intraspecific competition occurs among individuals belonging to the **same species**. This type of competition is generally intense because the ecological requirements of the individuals are very similar. It may involve:

- food resources,
- reproduction (access to mates, spawning or nesting sites),
- territory or living space.

Intraspecific competition contributes to the natural regulation of population size and influences natural selection by favoring the best-adapted individuals.

b) Interspecific competition

Interspecific competition involves individuals belonging to different species and is closely linked to the concept of the ecological niche. When two species exploit similar resources or occupy the same ecological niche, they inevitably compete. According to the principle of competitive exclusion (Gause's law), two species with identical ecological niches cannot coexist indefinitely in the same environment: in the long term, one of the species is either eliminated or forced to modify its niche (resource partitioning, spatial or temporal displacement).

Illustrative example

A classic example of interspecific competition is observed between the European pond turtle (*Emys orbicularis*), a native species, and the red-eared slider (*Trachemys scripta*), an invasive exotic species. These two species compete for access to basking sites, which are essential for thermoregulation.

In reptiles, body temperature is closely dependent on environmental temperature. Consequently, many physiological processes such as digestion, growth, reproduction, and movement are conditioned by ambient temperature. Sun exposure allows turtles to accumulate the heat necessary for their metabolism.

When basking sites are available in limited numbers, competition becomes more intense. The red-eared slider, often more aggressive and more competitive, can monopolize these sites to the detriment of the European pond turtle, thereby contributing to the decline of local populations.

4.2.2 Predation

Predation is one of the most conspicuous and widespread biological interactions among populations within ecosystems. It is an interaction of type (+/–), in which one organism, the predator, benefits by feeding on another organism, the prey, which generally suffers a fatal disadvantage.

In most cases, the predator and the prey belong to different species. However, cannibalistic behaviors may be observed in many animals, particularly under conditions of high population density or resource scarcity.

In a broad sense, a predator is defined as any free-living organism that feeds at the expense of another organism. This definition includes not only carnivores, but also herbivores, which can be considered predators of plants, as well as certain microorganisms that consume other microorganisms.

Parasitism can be considered a special case of predation. A parasite feeds on and develops at the expense of a host species but, unlike a typical predator, it does not necessarily aim to kill its host, at least in the short term, since its survival often depends on that of the host. According to their mode of life, parasites may develop:

- on the surface of the host, in which case they are referred to as ectoparasites (e.g., ticks, lice);
- inside the host, in which case they are referred to as endoparasites (e.g., intestinal worms, protozoa).

Within biocenoses**,** predation represents the primary driver of matter and energy transfer among the different trophic levels. It plays a fundamental role in structuring food webs and in the overall functioning of ecosystems.

From a demographic perspective, predation is an essential ecological process for population regulation**.** Prey abundance determines the growth rate of predator populations, while predation pressure influences the abundance, distribution, and evolution of prey populations. This interdependence may lead to cyclical fluctuations in population sizes**,** which are characteristic of predator - prey systems**.**

4.2.3 Mutualism

Mutualism is a biological interaction in which both partners gain a benefit, which can include protection, nutrient provision, pollination, seed dispersal, and more.

Example: Many protozoa or bacteria help various animals digest their food in exchange for a suitable habitat. This is the case for flagellates in the digestive tract of termites, which facilitate the digestion of cellulose.

Mutualism is a positive interaction between two organisms of different species, in which each partner receives reciprocal benefits. These benefits can vary in nature, including nutritional,

protective, reproductive, or ecological advantages. Mutualism plays a fundamental role in the functioning, stability, and evolution of ecosystems.

The advantages of mutualistic interactions may include:

- the provision of essential nutrients;
- protection against predators or parasites;
- plant pollination ;
- seed dispersal ;
- or the improvement of living conditions (shelter, microclimate).

Forms of mutualism

Two main forms of mutualism are generally recognized:

- obligate mutualism, in which the association is essential for the survival of one or both partners (e.g., termites and cellulolytic microorganisms);
- facultative mutualism, in which partners can live independently but gain an advantage from their association (e.g., pollinators and flowering plants).

Examples of mutualism

A classic example is found in termites and symbiotic microorganisms (flagellated protozoa and bacteria) residing in their digestive tract. Termites feed on wood, which is rich in cellulose, a molecule they cannot digest on their own. Symbiotic microorganisms produce cellulolytic enzymes that break down cellulose into sugars that termites can absorb. In return, these microorganisms benefit from a stable, nutrient-rich, and protected habitat.

Other examples highlight the ecological importance of mutualism:

- mycorrhizae, associations between fungi and plant roots that enhance water and mineral nutrient absorption;
- insect pollination, in which insects obtain nectar while ensuring the reproduction of plants;
- lichens, stable associations between a fungus and an alga or cyanobacterium.

Thus, mutualism is a key mechanism of coevolution, promoting species specialization and contributing to the maintenance of biodiversity and ecosystem stability.

4.2.4 Symbiosis

Symbiosis is a close and long-lasting biological interaction between two organisms of different species, in which both partners gain reciprocal benefits and maintain a functional dependence such that they generally cannot survive without each other. This relationship, of type (+/+), often involves coevolution of the partners and a high degree of biological specialization.

Symbiosis can be obligate, when the association is essential for the survival of the organisms, or facultative, when the partners can live independently but perform better when associated.

A classic example of symbiosis is lichens, which result from the intimate association between a photosynthetic alga (or a cyanobacterium) and a fungus. In this association, the fungus provides mechanical protection, a structural support, absorbs minerals, and retains moisture, thus creating a favorable microenvironment. In return, the alga performs photosynthesis and supplies the fungus with the organic nutrients necessary for its nutrition.

Thanks to this symbiosis, lichens are able to colonize extreme environments (bare rocks, arid zones, polar regions), where neither partner could survive alone. Symbiosis thus plays a major ecological role in habitat colonization, ecosystem functioning, and the stability of biological communities.

4.2.5 Commensalism

Commensalism is an asymmetric biological interaction of type (+/0), in which one partner benefits while the other experiences neither measurable advantage nor disadvantage. Unlike mutualism or symbiosis, commensalism does not involve reciprocal dependence between the organisms involved.

This interaction can provide various types of benefits, such as easier access to food, shelter, support, or favorable environmental conditions, without physiologically or ecologically affecting the host organism.

A classic example of true commensalism is the association between the cattle egret (*Bubulcus ibis*) and livestock. As the livestock moves, it disturbs numerous insects and small animals

hidden in the vegetation. The egrets take advantage of this activity to capture prey more easily, thereby increasing their food intake. The livestock, in turn, neither benefits nor suffers from the presence of the birds.

4.3 Ecological niche

Organisms of a given species can only maintain viable populations within a well-defined set of environmental conditions, using specific resources, in a given habitat, and during particular periods. The combination of these ecological factors defines the ecological niche, which corresponds to the functional role occupied by a species within its environment.

The ecological niche encompasses:

- Abiotic conditions (temperature, humidity, light, pH, etc.),
- Resources utilized (food, shelter, reproductive sites),
- Biotic interactions (competition, predation, symbiosis),
- and the temporal dimension, i.e., the periods of activity of the organism (diurnal/nocturnal, seasonal).

This concept is often summarized by the expression:

One species = one ecological niche", meaning that each species occupies a specific niche shaped by its evolutionary history. A niche is frequently associated with a certain degree of specialization, notably in terms of diet, but also spatially or behaviorally. High specialization allows efficient exploitation of resources but also makes the species more vulnerable to environmental changes.

Example

Common toads illustrate well the variation of niche throughout their life cycle. At the larval stage, tadpoles inhabit an aquatic environment, feeding mainly on algae and detritus. After metamorphosis, adults become terrestrial and adopt an **insectivorous diet**. Thus, a single species can occupy multiple successive ecological niches depending on its developmental stage.